Proc. Gulf Carib. Fish. Inst., 23d Annu. Sess., 139-148, 1971

The Distribution of Sediment Properties and Shrimp Catch on Two Shrimping Grounds on the Continental Shelf of the Gulf of Mexico[1]

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Abstract

During 1966-68 sediment samples were collected on an intensive scale from shrimping grounds of the Dry Tortugas, Florida and off Galveston, Texas. The areas were described by sediment types and organic carbon content. Comparisons were made between the shrimp catches and the distribution of sediment properties.

Sediment properties and distribution differ notably between the Tortugas and Galveston areas. Within the Tortugas grounds a thin veneer of organically derived sediments overlies a limestone substrate. Carbonate sands constitute 78% of the surface sediment. The remaining area is covered principally by a very coarse silt. In contrast, the area off Galveston is a relatively smooth dipping detrital bottom with sediments of terrigenous origin. Sand and sand-silt-clay types are the most abundant sediments present.

Comparison of the distribution of sediment properties outside the grounds with the distribution of sediments within the Tortugas grounds seems to indicate the fishing grounds have a relatively high content of organic matter. Certain sediment types appear in the area of high catch. In the Galveston area the patterns of sediments and organic matter are more diverse and relationships less clear. Further study of the sediment properties and the shrimp catch on the continental shelf is in progress.

INTRODUCTION

The association of adult shrimp of the genus *Penaeus* on the open continental shelf with certain types of bottom sediments has long been recognized by fishermen. Only recently, however, have these sediment types and their distribution over the fishing grounds been investigated (Burkenroad 1939, Gunter 1950, Williams 1955, Hildebrand 1955, and others). From their investigations in the field, Springer and Bullis (1954) and Hildebrand (1954) found pink shrimp abundant on calcareous mud and shell sands, and white and brown shrimp abundant on terrigenous silt. From laboratory experiments Williams (1958) concluded that the distribution of penaeid shrimp over these certain types of substrates was not random and that other factors could qualify this relationship. Of these, the most influential parameter is food. Because of the difficulty of determining the distribution and abundance of shrimp and the total amount of food available on the continental shelf, little progress has been made on the relationship between the distribution of shrimp, particle size, and organic matter.

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[1] Contribution No. 318 from the National Marine Fisheries Service Biological Laboratory, Galveston, Texas.

To determine if a relationship could be shown in the field between the shrimp, sediment types, or organic matter, the distribution of surface sediments on two fishing grounds were compared with the distribution of shrimp based on shrimp catch. In this preliminary report only gross relationships are considered and no distinction was made between the different commercial species of adult shrimp. The study did not include the very productive fishing grounds southwest of Galveston because sampling was incomplete. Collection of samples from this area is continuing with the aid of the Texas Parks and Wildlife Department.

METHODS

Bottom sediments were collected during the 1966-68 cruises of the R/V *Geronimo* in the vicinity of the Dry Tortugas and off Galveston (Fig. 1). Surface sediments were taken with a Van Veen grab and the top centimeter or two of the sample was scraped off for analysis. The coarse fractions - sand to gravel - were separated into grade sizes by sieve, and the fine fractions - silt and clay - were determined by pipette analysis. The percentages of sand, silt, and clay were plotted on triangular diagrams (which accompany the sediment distribution charts) and the sediment types were named after the classification of Shepard (1954) for the Gulf Coast. Sediment types are based on particle size and not qualified by the composition of the sediment. The organic matter is based on the amount of organic carbon present in the sediment. Because organic carbon represents from 50 to 60% of the total organic matter in the sediments, the approximate total organic matter can be estimated by multiplying by 1.8 which is equivalent to a carbon content of 56% (Trask, 1955). Organic carbon was determined by grinding the samples to a size of less than 250 microns, digesting the calcium carbonate with a weak solution of hydrochloric acid, and determining the remaining carbon by use of an induction furnace and direct readout carbon analyzer.

The shrimp catch data for the Dry Tortugas grounds are based on landings that cover 2 years from September 1963 through August 1965 (Lindner, 1965). The shrimp catch data for the Galveston grounds were collected by Galveston laboratory personnel from interviews with fishermen from July through September 1964. The data were plotted in thousands of pounds per hour by areas of 100 square nautical miles.

Tortugas Grounds

In the study of the distribution of the surface sediment types it was advisable to determine the bottom topography in sufficient detail to be of aid in the interpretation of the data. We therefore prepared a bathymetric chart of the southern Florida shelf and Tortugas grounds on a Lambert conformal projection contoured at 1-meter intervals (Fig. 2).

The bottom on the southern Florida shelf is a hard limestone substrate overlaid by a thin veneer of biogenic sediments. Ancient reefs, pinnacles, and ridges are prominent at the edge of the shelf. Water depth at the shelf break, from 70 to 77 meters (38-42 fathoms), is relatively shallow compared to the world average of 137 meters (75 fathoms). The average dip of the shelf from shore to the break is about 3.2 ft. per nautical mile. North of the fishing grounds the bottom is irregular, spotted by algal mounds, coral cappings, pinnacles, and numerous shallow depressions that extend seaward to a depth of 37 meters (20

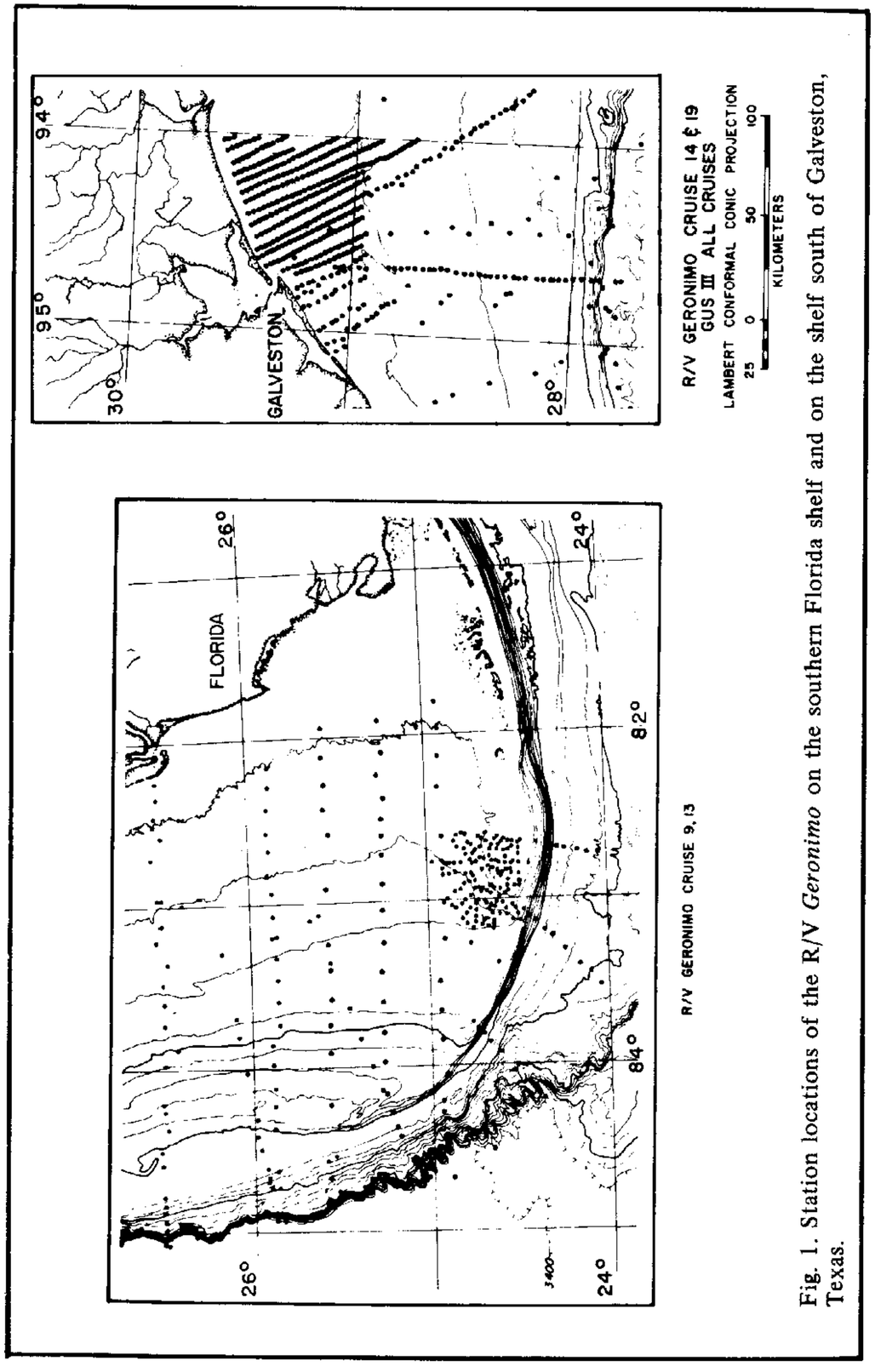

Fig. 1. Station locations of the R/V *Geronimo* on the southern Florida shelf and on the shelf south of Galveston, Texas.

fathoms). Relief of these features does not exceed in general 33 feet. The most abundant sediment type on the southern Florida shelf is sand with widely separated patches of gravel composed principally of coarse shell, coral, and algal fragments.

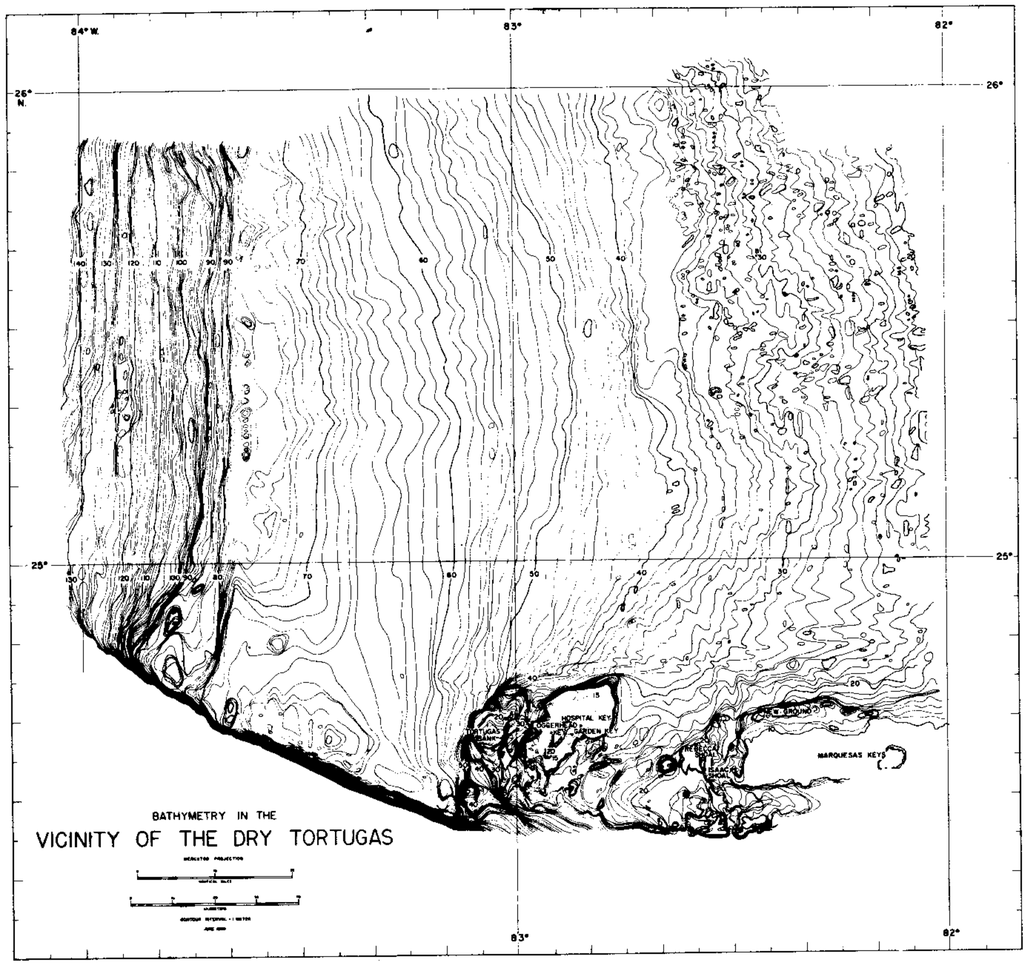

Fig. 2. Bathymetry of the southern Florida shelf.

The distribution of sediment types on the Tortugas fishing grounds is shown in Figure 3. Within the grounds, sand and silty sand are abundant. Sandy silt, the only other abundant sediment type present, occurs in a prominent strip aligned east-west just north of New Ground, Rebecca Shoal, and Dry Tortugas. Several small areas of clayey silt are present north of the Dry Tortugas, but no clay or sand-silt-clay types were dredged.

North of the fishing ground the average value of the total organic carbon content of the sediment based on similar depth intervals is considerably lower than on the fishing ground and increases slightly in deeper water (Fig. 4). Lindner (1965) divided the Tortugas fishing grounds north of New Ground and the Dry Tortugas into four zones, areas A, B, C, and D in Figure 4. The zones are essentially depth intervals and bound approximately, from east to west, the

intervals 9-12, 12-18, 18-24, and 24-30 fathoms. Average values of organic carbon are 0.28% for the 9-12 fathom depth interval and 0.32% for the 24-30 fathom interval. Over the same depth intervals within the grounds the average percentages of organic carbon are all higher and more than double in area C. The average organic carbon content within area A, 9-12 fathom interval, is 0.54% which increases to a maximum average of 0.71% in area C, 18-24 fathom interval. In area D, 24-30 fathoms, the organic carbon decreases to 0.70%. This seaward increase in organic carbon results primarily from the occurrence of finer-grained sediments north of the Dry Tortugas. The higher percentages of organic matter in a sample are usually contained in the finer particle sizes of the sediment.

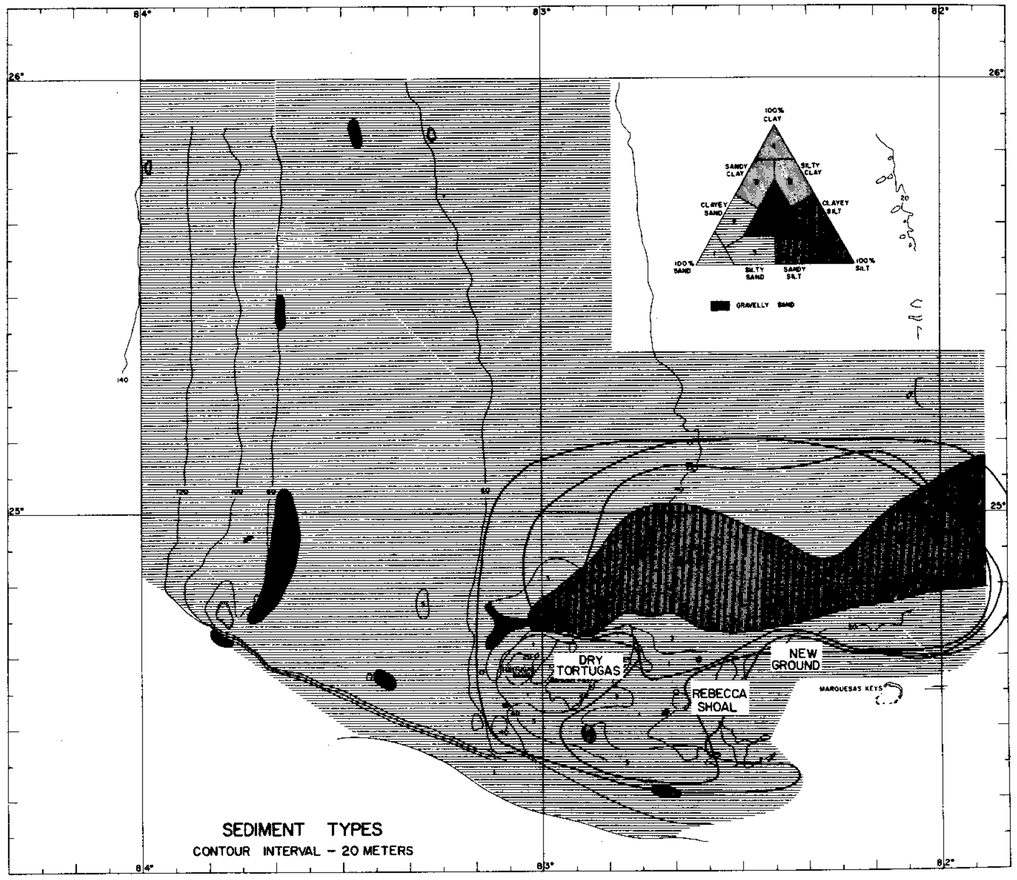

Fig. 3. Distribution of sediment types over the Dry Tortugas fishing grounds. Heavy lines encircling shrimping ground are different versions of its extent.

Shrimp landings for each area, proceeding seaward from A to D, are respectively 25, 68, 6, and 1% of the total landings.

A comparison of the average organic carbon content of sediments within the fishing grounds with the content outside shows the grounds have a considerably higher organic carbon content; some areas contain more than twice as much organic carbon. Sandy silt is the predominant sediment within the grounds.

Galveston Grounds

On the western continental shelf, off Texas, recent terrigenous deposits are in the process of covering the older sands although large areas of the relict surface still remain. Transport of these sediments from bays and rivers has produced a pattern of interfingering sands, silty clays, and sand-silt-clay types near shore. Recent sand is generally not deposited offshore in depths greater than 5 fathoms and the suspended load of the currents does not usually cover the bottom more than 20 to 25 miles offshore (Curray, 1960).

An important process less well known is the transport of sediment across the shelf by sediment plumes. They are similar to rip currents and carry fine detrital material well out on to the shelf. Although widely fluctuating throughout the year, they are believed to be semipermanent features and account in part for the irregular and patchy distribution of modern sediments over the shelf. A

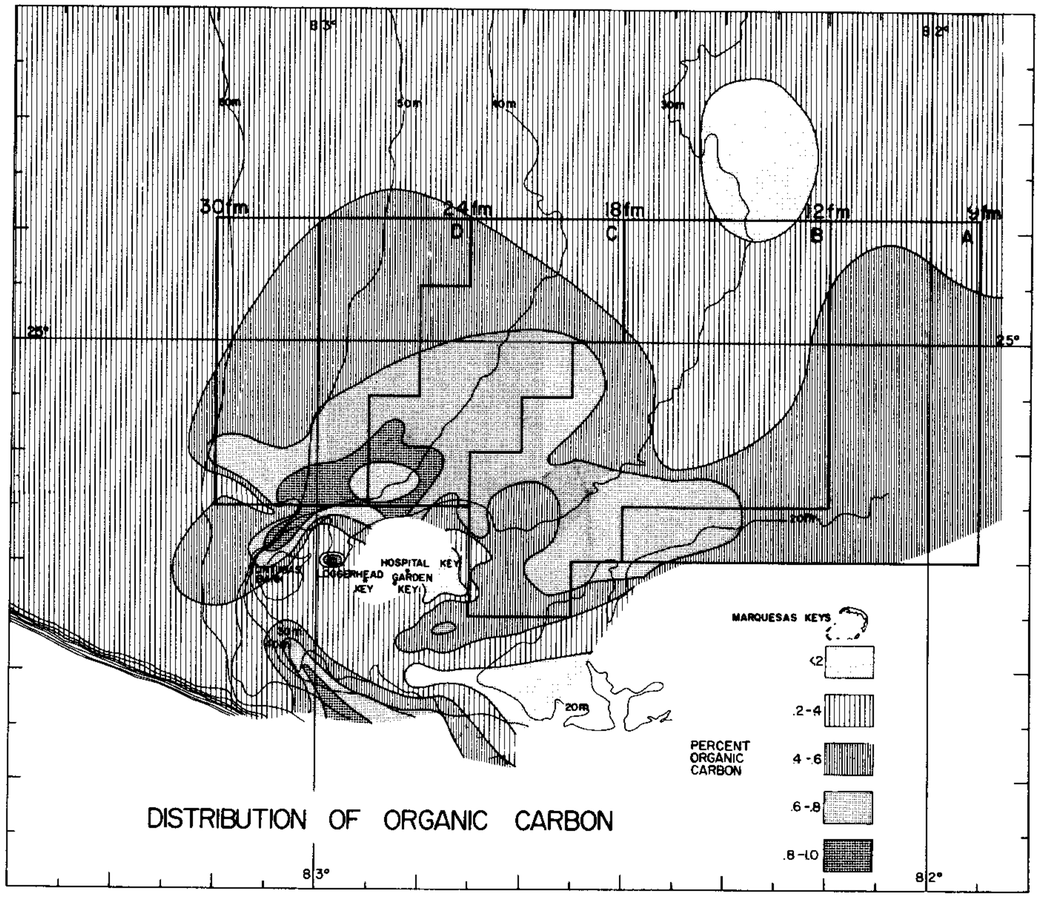

Fig. 4. Distribution of percent organic carbon in the vicinity of the Dry Tortugas. Blocks A, B, C, and D divide the fishing grounds into depth zones.

relationship between shrimp catch and the large plumes south of Galveston Island was established by Lindner and Bailey (1969). Within the shrimp fishing grid zone No. 18 and part of No. 17 south of Galveston Island, more than 57%

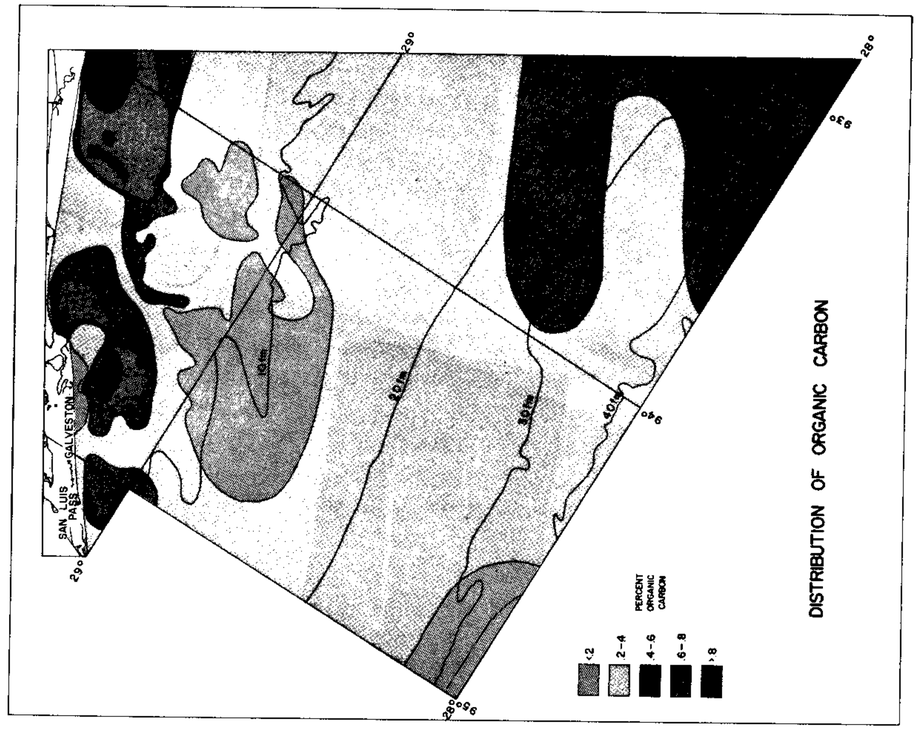

Fig. 6. Distribution of percent organic carbon in sediments over the fishing grounds south of Galveston, Texas.

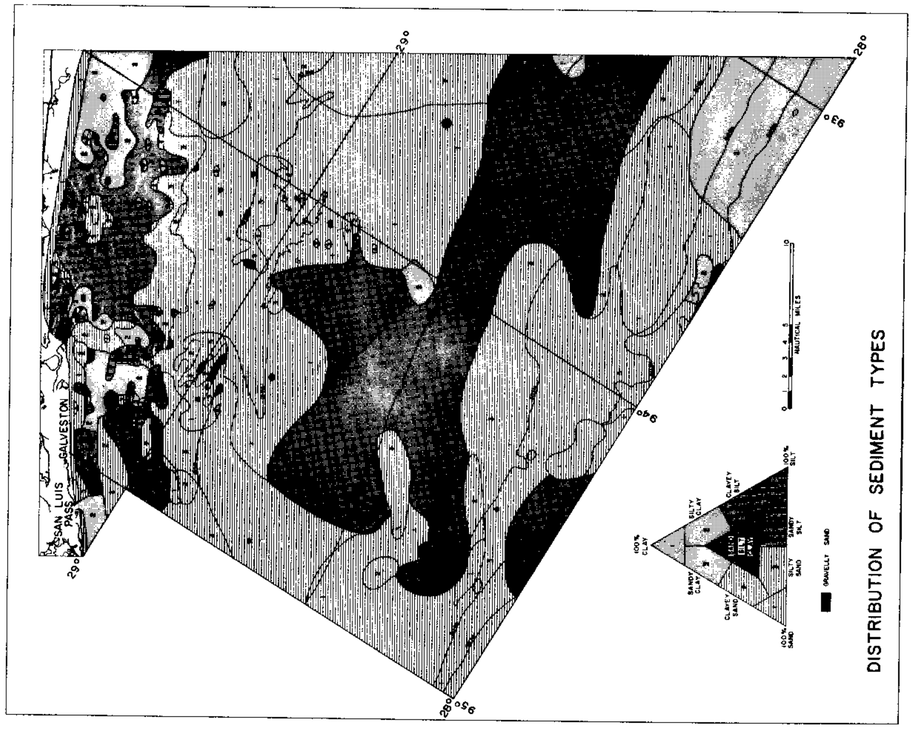

Fig. 5. Distribution of sediment types on the shelf south of Galveston, Texas, in shrimp fishing grid zone 18 and part of 17.

of the surface sediment is a sand and about 35% is a sand-silt-clay type (Fig. 5). The sand-silt-clay is a type in which all three sediment classes are present in amounts greater than 20%. A small amount of silty clay is present principally among the nearshore sediments and well offshore around the 40 to 50 fathom contours beyond the main fishing area. Silt is almost absent on the grounds.

The distribution of the organic carbon in the sediments is shown in Figure 6. The areas of high organic carbon, greater than 0.4%. are associated with the sand-silt-clay and silty clay. The silty clay, because of its fine particle size, can have areas within its distribution that are high in organic carbon similar to the fine-grained clayey silts of the Dry Tortugas grounds. Sand is low in organic carbon, containing less than 0.4%. The shrimp catches from July through September 1964 are shown in Figure 7. Compared to the Tortugas grounds the relationship between the sediment type, organic content, and catch is more complex. Although the catch is irregularly distributed over the entire grounds, maximum catches occur principally in two areas. The major one is aligned generally in the area of the 20 fathom isobath and the other off Galveston Island. The sediment type sand-silt-clay is present within all the blocks of maximum catch. The organic carbon content is generally high in the areas of maximum catch.

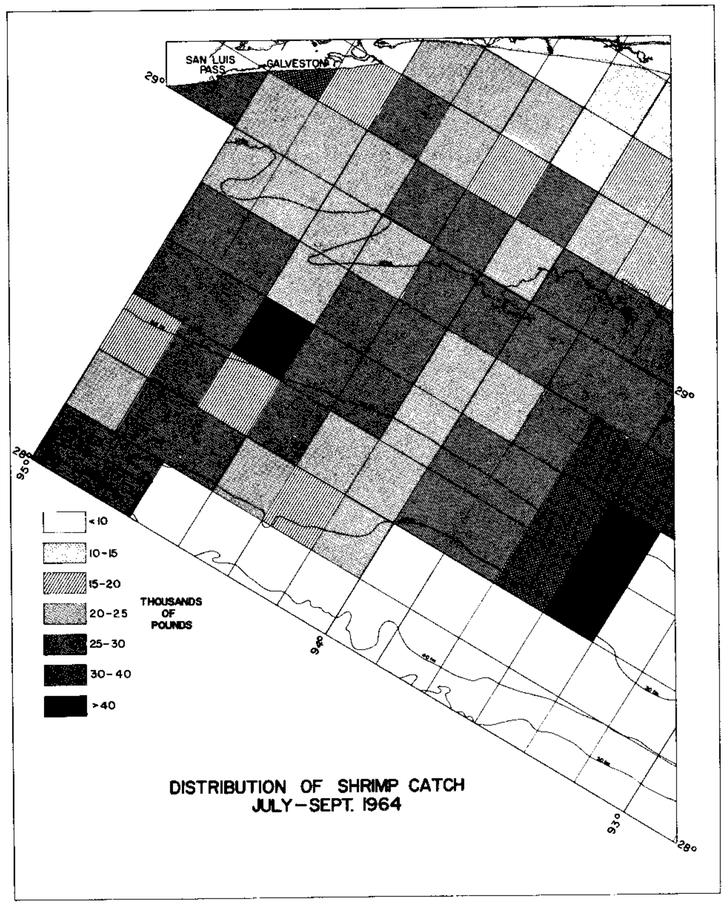

Fig. 7. Distribution of shrimp catch-effort, July-Sept. 1964 in the shrimp fishing grid zone 18 and part of 17.

SUMMARY

The sedimentary type most abundant in both fishing areas is sand. The most abundant catch, however, is associated with a sandy silt in the Dry Tortugas grounds and a sand-silt-clay in the Galveston grounds. The entire fishing grounds seem high in organic matter in comparison to areas outside the grounds.

Although only the gross distribution of commercial adult shrimp and sedimentary properties were considered, the results seem to indicate that fishing areas of large catch may have a high content of organic matter.

Other conditions certainly have an effect on the distribution of shrimp and may be influential in determining their movements over the grounds.

A study to determine if the distribution of particle size and organic matter show a relationship to the shrimp landings over the northern continental shelf of the Gulf of Mexico based on the data from shrimp fishing grid zones is in progress.

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